CLAIMS

1. A manufacturing method of a piezoelectric element including the steps of forming a lower electrode on a substrate, forming a piezoelectric film on the lower electrode, and forming an upper electrode on the piezoelectric film,

wherein, in the step of forming the piezoelectric film, steps of forming a piezoelectric layer are carried out a plurality of times, whereby a plurality of the piezoelectric layers are stacked, the steps of forming the piezoelectric layer including applying a sol containing an organometallic compound, drying the sol containing the organometallic compound, degreasing the sol containing the organometallic compound so that the sol is gelated, and crystallizing the gelated organometallic compound, and

when forming a lowermost layer of the piezoelectric layers, a rate of temperature increase during at least initial degreasing thereof is set to 500°C/min or lower.

2. The manufacturing method of a piezoelectric element according to claim 1, wherein, when forming at least one layer of the piezoelectric layers except for the lowermost layer, the rate of temperature increase during degreasing thereof is set to be 1000°C/min or higher.

3. A manufacturing method of a piezoelectric element including the steps of forming a lower electrode on a substrate, forming

a piezoelectric film on the lower electrode, and forming an upper electrode on the piezoelectric film, wherein, in the step of forming the piezoelectric film, steps of forming a piezoelectric layer are carried out a plurality of times, whereby a plurality of the piezoelectric layers are stacked, the steps of forming the piezoelectric layer including applying a sol containing an organometallic compound, drying the sol containing the organometallic compound, degreasing the sol containing the organometallic compound so that the sol is gelated, and crystallizing the gelated organometallic compound, and

when forming a lowermost layer of the piezoelectric layers, a rate of temperature increase during at least initial degreasing thereof is set to be equal to or lower than that during degreasing of the other piezoelectric layers.

4. The manufacturing method of a piezoelectric element according to claim 3,

wherein, the step of forming the piezoelectric film includes: forming a first piezoelectric layer, which is the lowermost layer of the piezoelectric layers, on the lower electrode provided over an almost entire surface of the substrate; patterning the lower electrode and the first piezoelectric layer to have a predetermined shape; and forming another piezoelectric layer to cover end surfaces of the lower electrode and the first piezoelectric layer, and

the rate of temperature increase during degreasing for forming the first piezoelectric layer and a second piezoelectric

layer provided directly on the first piezoelectric layer is set to be equal to or lower than that during degreasing for forming the rest of piezoelectric layers.

5. The manufacturing method of a piezoelectric element according to claim 4, wherein, each of the first and second piezoelectric layers are formed by applying a sol containing the organometallic compound once, followed by galation and crystallization of the sol, and the rest of the piezoelectric layers are formed by applying the sol containing the organometallic compound twice or more, followed by gelation and crystallization of the sol.

6. The manufacturing method of a piezoelectric element according to any one of claims 4 and 5, wherein, after the lower electrode and the first piezoelectric layers are patterned, crystal seeds which become nucleuses of the piezoelectric film are continuously formed from the first piezoelectric layer through outer sides thereof.

7. The manufacturing method of a piezoelectric element according to any one of claims 4 to 6, wherein the lower electrode and the first piezoelectric layer are patterned by ion milling.

8. A manufacturing method of a piezoelectric element, including the steps of forming a lower electrode on a substrate, forming a piezoelectric film on the lower electrode, and forming an upper

electrode on the piezoelectric film,

wherein, in the step of forming the piezoelectric film, steps of forming a piezoelectric layer are carried out a plurality of times, whereby a plurality of the piezoelectric layers are stacked, the steps of forming the piezoelectric layer including applying a sol containing an organometallic compound, drying the sol containing the organometallic compound, degreasing the sol containing the organometallic compound so that the sol is gelated, and crystallizing the gelated organometallic compound, and

the rate of temperature increase during degreasing of at least the piezoelectric layer formed by initial crystallization is set to be equal to or lower than that during degreasing of the rest of piezoelectric layers formed by following crystallization.

9. The manufacturing method of a piezoelectric method according to any one of claims 1 to 8, wherein, when the degreasing is performed, the sol is heated from a side of the substrate.

10. A manufacturing method of a liquid jet head, wherein a piezoelectric element made in the manufacturing method of any one of claims 1 to 9 is used.

11. A piezoelectric element which includes a lower electrode, a piezoelectric film formed on the lower electrode, and an upper electrode formed on the piezoelectric film,

wherein the piezoelectric film includes a lower layer portion having column crystals, and an upper layer portion having column crystals which are continuous from those in the lower layer portion and have sizes larger than those in the lower layer portion.

12. The piezoelectric element according to claim 11,

wherein the lower electrode is patterned to have a predetermined shape, a first piezoelectric layer, which is a lowermost layer of a plurality of piezoelectric layers constructing the piezoelectric film, is formed only on the lower electrode, and the rest of the piezoelectric layers are formed, covering end faces of the lower electrode and the first piezoelectric layer, and

the first piezoelectric layer and a second piezoelectric layer formed directly on the first piezoelectric layer construct the lower layer portion.

13. The piezoelectric element according to claim 12, wherein a thickness of each of the first and second piezoelectric layers is thinner than that of each of the rest of the piezoelectric layers.

14. The piezoelectric element according to any one of claims 12 to 13, wherein the end faces of the lower electrode and the first piezoelectric layer are inclined at a predetermined angle with respect to surfaces thereof.

15. The piezoelectric element according to any one of claims 12 to 14, wherein metallic layers, which are electrically disconnected from the lower electrode, are provided in vicinities of edges of the piezoelectric film.

16. A liquid-jet head, comprising the piezoelectric element according to any one of claims 11 to 15 as a driving source of liquid ejection.